Space Weather Technical Forecast

Issued on Friday, 28 April 2023 at 13:17 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Several unassessed CME candidates awaiting imagery. Else decreasing Chance of G1 through period. Chance R1/R2 throughout. Return of Active electron fluence Likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity fell to Low in the past 24 hours, with an overall increase in occasional C-class activity and a peak of a long-period C6.6 at 28/0122UTC from AR3285 and perhaps also a component from AR3288 in the south-centre disc. These formed two of the seven current front-sided sunspot regions, with AR3290 having faded to plage in the northeast as a new unnumbered unipolar spot grew nearer the solar meridian. Although the narrow viewing angle is precluding any analysis, there also appears to be a brightening EUV flux region on the southwestern limb at present.

The largest and nominally most potent sunspot group on the disc remains AR3288, which has a central Mt Wilson delta, and a candidate for a second, in a slowly reconfiguring Esi/BGD. AR3285 to its immediate northwest looks more benign in HMIIF, be there is clearly some interconnection between the two. The main other spot group that saw changes in the period was AR3291, which saw spreading, leading spot growth and consolidation.

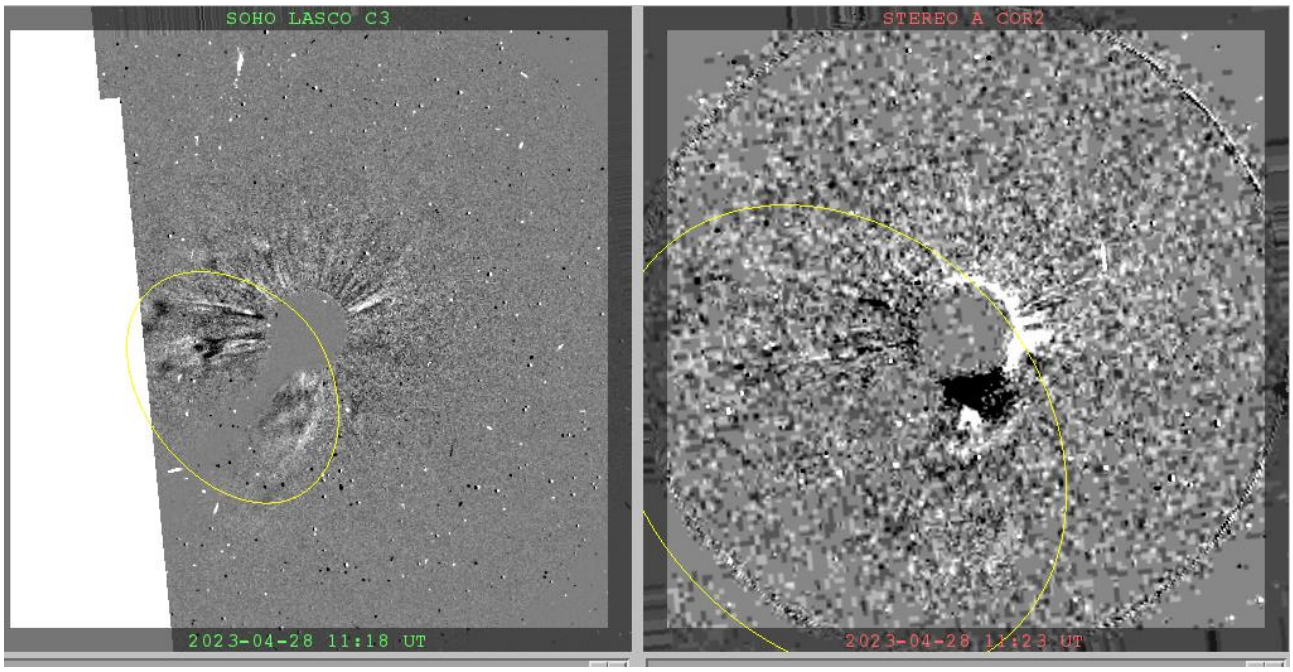

Figure 0: Lasco C3 and STEREO A COR2 difference imagery, showing ringed in yellow some of the ejecta undergoing assessment (the elipse not suggesting the east and southward portions are linked).

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Filament and dimming activity in the period has been more complex - there have been numerous fragmentary eastward-directed small CMEs in the past 48 hours, including one awaiting modelling results, with the source inferred from analyses as perhaps being near 50 East - the latest perhaps from a minor dimming at this longitude at 27/2100UTC. None of these new eastward-directed CMEs feature in the forecast at present, but MOSWOC Enlil ensemble does have a close pass signalled for 30 April from one of the many emitted in the UTC day of 27 April, which would prolong the risks of minor disturbances from CMEs that feature in the forecast in the run-up (i.e. the chances of glances from the 25 April and 26 April mainly southwest-directed filaments loading the bases on 28 and 29 April beforehand).

Also of note on coronagraph imagery were up to two mainly southward-directed CMEs becoming visible in Lasco C2 into the current UTC morning. Analysis of these events will be conducted when further imagery becomes available. Sources for the southward-heading CMEs are not definitive, but may perhaps be very tentatively correlated with the long-period C6.6 at 28/0122UTC (AIA094 ejecta appeared helicoidal) and perhaps a C2.9 flare and dimming near S20E020 around 28/0530UTC.

Rounding off a busy 24 hours, a large prominence eruption left the southwest disc around 28/1100UTC. There is not yet any coronagraph imagery for this event.

All these aspects will be monitored, but as a result, the forecast should be considered of lower than average confidence and liable to change.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by ACE and DSCOVR at L1, was mainly reflective of continuing fast wind enhancement from CH96/-, although this signature became less clear from 28/0800UTC given erratic DSCOVR traces.

The solar wind speed showed a mainly flat trend at Strong levels of around 600km/s, but with ACE suggesting a step-wise increase to the high 600s after 0800UTC as DSCOVR flitted between 500 and the upper-600s. The phi angle, which had been solidly negative (towards the Sun) up to this point became more unstable, and the IMF became more erratic and of lower magnitude - from a previous smooth and steady 7nT or less. The north-south component remained changeable throughout, with a range of +/-6nT. Finally the density trace was noisy, but appeared to be at or near single figures ppcc throughout at both DSCOVR and ACE.

The net effect of the above solar wind measures was Unsettled to Active, with a provisional peak Kp of 4+ in the 15-18UTC interval.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, has been at Background levels throughout, with no obvious response from the M1.8 flare at 27/1113UTC from AR3288 centre-disc.

High energy electron flux (greater than 2MeV) as measured at GOES16, showed an increasingly attenuated scope between High and Background flux, peaking at 3360pfu at 27/1635UTC. The 24-hour integrated fluence showed a slightly declining tendency, with the 28/0001UTC fluence level being 9.3e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to remain Low, with a Chance of reaching Moderate levels. No significant regions leave and no returning regions are currently expected to rotate onto the visible disc, leading to a flat trend of probabilities.

Solar Wind / Geomagnetic Activity: The current coronal hole fast wind will dominate the forecast

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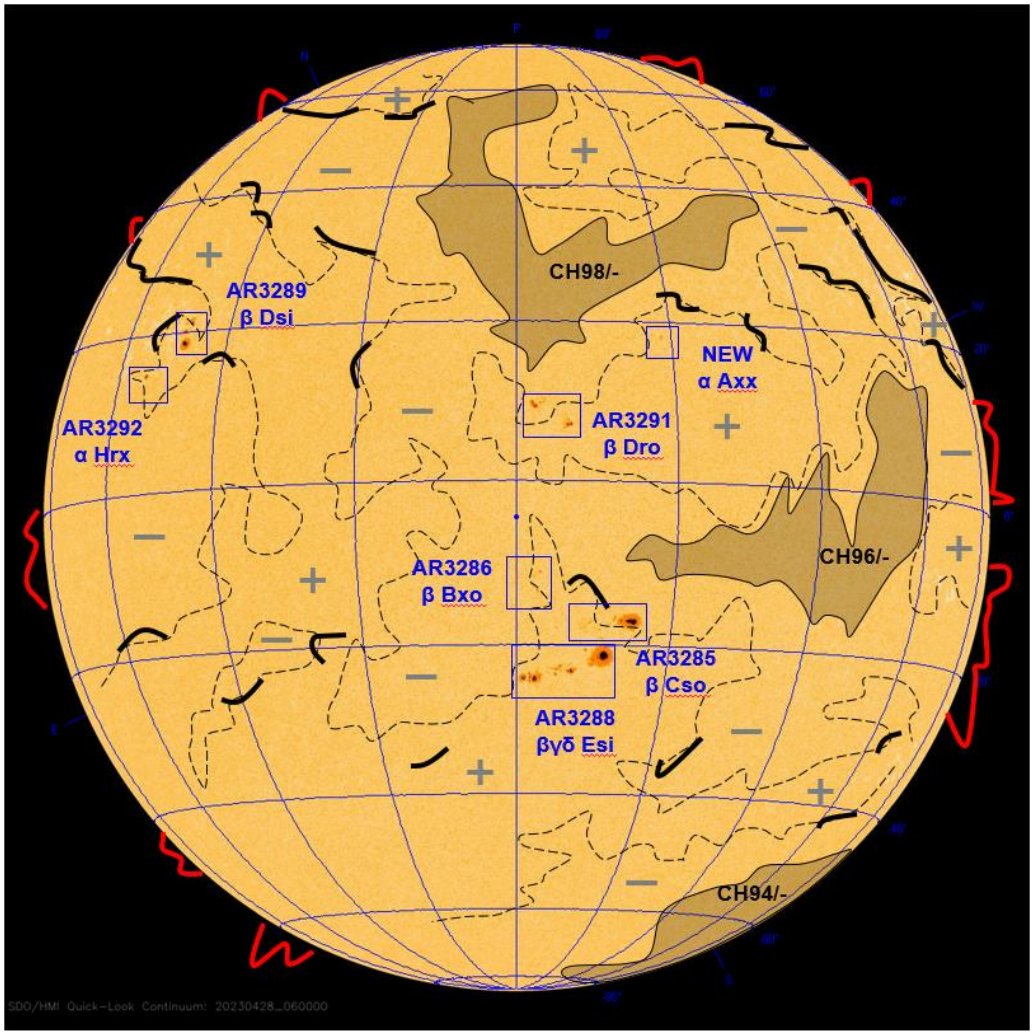
period, fading from current Strong levels later in the UTC weekend. This may be overlaid by up to three CMEs, all forecast misses, but with MOSWOC ensemble members showing minor glances are possible. Respectively, these are 25, 26 and 27 April filament eruptions, due to pass 1AU on 28, 29 and 30 April. There are now also further unassessed candidates for CMEs that render the current forecast low confidence and subject to change - pending imagery for analyses.

The current forecast is for a Chance of G1 starting the period, falling to a Slight Chance by the end of the coming UTC weekend, then largely Quiet into the new working week.

Energetic Particles / Solar Radiation: Overall no solar radiation storms are expected, but there is a slight chance of a storm occurring over the four days - mainly due to the westward advance of AR3288.

High energy (greater than 2MeV) electron flux at GEO is currently being suppressed by geomagnetic activity, but is Likely to respond upward strongly once this eases, with an increasing likelihood of Active fluence being restored in the period.

Figure 1. Solar Analysis Valid 28/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The past 12 hours have seen numerous apparently small candidates for CMEs that are undergoing analysis or awaiting imagery - in part discussed in the 'Solar Activity' section. Visually these appear to be mainly directed east and south of the Sun-Earth line, but this does not preclude some Earth-directed component(s). Until confirmatory imagery and modelling results are available, the geomagnetic forecast can be considered to hold greater than average uncertainty and be subject to change.

The current forecast consists of one main fast wind - the incumbent high speed stream from CH96/-, which may be peppered with minor glancing incidence CMEs over the first three days of the period.

The posited CMEs are: a 25 April filament eruption passing 1AU on 28 April; a 26 April filament eruption passing on 29 April, and now also potentially a CME related to the 27/0200UTC northeast filament, passing on 30 April. This final event was modelled as at least three separate CMEs, with several more minor emissions following the main event along a similar track. All of these events are most likely to miss Earth - as shown in the MOWOC Enlil deterministic run - but a minority of ensemble members have some perturbation to the wind indicated up to and over the UTC weekend.

The unperturbed fast wind from CH96/- should otherwise continue in much the same vein as it has to this point, with current Strong solar winds eventually abating later in the UTC weekend to leave an increasingly Quiet new working week. As such, the current risk of G1 peaks at a Chance on day one, Friday 28 April, and from here reduces to a Slight Chance through to Sunday 30 April.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	20	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil in deterministic run, some unassessed candidates. High uncertainty.

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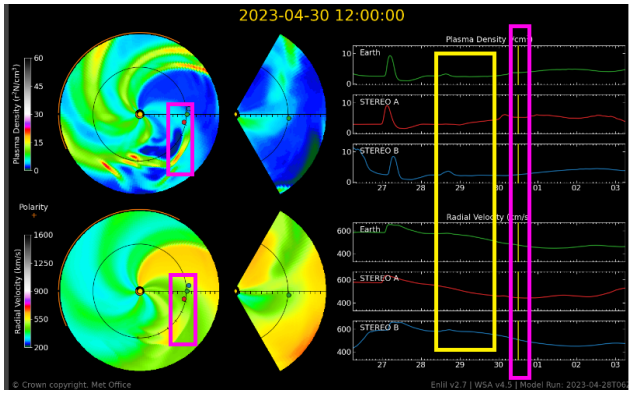
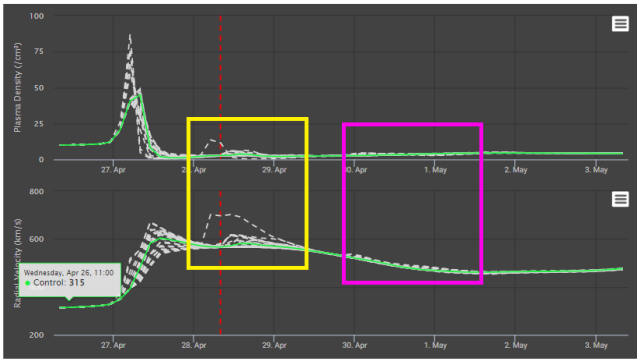
Figure 2: Latest MOSWOC Enlil run and ensemble, showing the 600km/s fast wind in the detrministis run from current CH96/-. Looking at the ensemble, this may be potentially enhanced by the 25 and 26 April CMEs' glancing incidence (boxed yellow), and the 27 April filament CME (boxed magneta). The earlier stronger hit was modelled from a 24 April CME that missed Earth.





Radio Blackouts - X-Ray Flares:

Only the small, simple AR3290 is expected to leave the Earth-facing side in the period. In terms of returning Carringtons and persistent regions on the far side, there are none due. In addition, the northeast limb has yet to reveal any bright flux that may betray a sunspot region on the limb here, as suggested in previous guidance from possible CME evidence.

Solar activity carries a Chance of further Moderate activity given any isolated M-class flares, with these still considered most likely from AR3288.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

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Figure 3: Sources of X-ray flares of C-class and above over the 24-hour period, processing courtesy of SIDC ROB. In the northeast, AR3289 has quietened relative to ealier in the week, as AR3285 has strengthened to the immediate northwest of AR3288.

Solar Radiation Storms - (High Energy Protons):

No solar radiation storms are expected, but there is a Slight Chance of a storm occurring over the four days due to the westward advance of AR3288. No enhancement was seen from the 27/1113UTC M1.8 flare from AR3288 centre-disc, although there is no guarantee that this would be repeated given similar-scale activity further west.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2MeV) electron flux at GEO has shown an eroded oscillation between High and Normal Background flux, although there are again signs that a strong recovery is possible whenever lulls in geomagnetic activity occur.

Persistence and the forecast from MOSWOC REFM both suggest Active 24-hour integrated fluence is Likely in the four days, probably becoming more likely with time in response to the Strong solar wind as the brakes of repeated Active Kp intervals ease. There are caveats to this forecast given the number of minor and unassessed CMEs that may feature in the four-day period, however with the CMEs that do currently feature most likely to miss, the rising trend in fluence is a reasonable bet.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	40	60	70	70
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	5	10	10

Figure 4: Past three days in high energy electron flux at GEO (top), and resulting 24-hour integrated fluence (bottom, blue dots). The MOSWOC REFM forecast and persistence suggestions of fluence near 1e8 integrated pfu are thought likely in the absence of significant CMEs, with the trend perhaps more resolutely upwards than shown. Uncertainty in this forecast is nevertheless higher than average given the CME forecast.

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